SP

N64-18450 *

CODE-1

(NASA CR-53571;

19p.

Planning Report No. 35-6

(Revision No. 1)

JPL-Planning Rept. 35-6 (Rev. 1)) OTS:

A Technique for Estimating Funding and Manpower Requirements for Research and Development Long-Range Planning

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JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA

1301823

November 8, 1962 19p

OTS PRICE

XEROX $ 1.60 ph

MICROFILM $ 0.80 mf.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
(NASA CONTRACT ~~NO.~~ NAS 7-100)

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I. INTRODUCTION

In order to facilitate long-range planning, a method has been evolved at this installation by which resource requirements to accomplish a given mission schedule can be grossly estimated. The method is by nature sensitive to the mission schedule, and the over-all estimates of the resources requirements can be easily adjusted should changes in the mission schedule occur.

It is the purpose of this report to outline the technique which has evolved from a study of the long-range programming problem. The material herein is extracted from an internal planning report and is presented only as one method by which estimates of resource requirements can be made. Charts and figures required to understand the technique are presented together with a simplified step by step procedural example showing how estimated requirements are determined for a given project which, in itself, is a component part of a program and of the overall installation effort. AUTHOR

II. A TYPICAL FLIGHT MISSION SCHEDULE

Based on the "typical mission schedule" shown in Fig. A-1 (Appendix A), the requirements for funding and manpower for the ensuing fiscal years have been determined. The schedule shown in Fig. A-1 is strictly a representative one for which this Installation would be responsible in carrying out its commitments to NASA during the next few years. In looking at the funding and manpower problems, an effort was made to keep the information separated into two categories: (1) that required for the several flight programs and (2) that required for supporting research and technology (SRT). Within the flight programs, the funding for each project is determined by taking the product of spacecraft weight, number of spacecraft, and a cost factor (dollars per pound) for each type, weight, and number of spacecraft. (See Figs. B-1 and B-2 of Appendix B.) Total funding for the flight programs in any given year is equal to the sum of the funding of the component projects for that fiscal year. Once the total project funding has been determined, annual portions of the total are distributed in a roughly sinusoidal pattern over the fiscal life of the project.

Table A-1 (Appendix A) gives a generalized description of, and implementation plan for, the projects within the typical Lunar and Planetary Programs.

Table A-2 (Appendix A) presents total Installation funding required for the typical total mission schedule as shown in Fig. A-1.

Table A-3 (Appendix A) presents the total manpower requirements to accomplish the same mission schedule for the same time period. Again the information is separated into the same two categories as indicated above.

Table A-4 (Appendix A) shows the total funding for supporting research (SR), advanced development (AD), and others from Table A-2 and the corresponding manpower totals from Table A-3 broken down according to the activities which contribute to those totals.

In Table A-5 (Appendix A) estimates are made of the yearly out-of-house funding fraction for each project (project procurements divided by total project funding). The theoretical relationship between out-of-house funding fractions and dollars per man-year then permits a determination of the total manpower required for the project in a given year. (See Tables A-4 and A-5 and Appendix C.)

III. PROCEDURAL EXAMPLE

The example below indicates the manner in which the funding and manpower requirements for a typical project (Project A) were determined over the duration of the project using the technique previously outlined.

For the purposes of this example, reference is made to the Project A information shown in the Figures and Tables of Appendices A, B, and C.

A. Total Project Funding Requirement

$$\text{Spacecraft weight} \times \text{Number of Flights} \times \text{Cost/lb} = \$ \times 10^6$$

$$1200 \times 4 \times 10 = 48$$
$$2360 \times 12 \times 7 = 198$$
$$4500 \times 8 \times 6 = 216$$

These cost estimates are recorded as separate items under the Project A-class spacecraft heading of Table A-2 (Appendix A).

B. Yearly Distribution of Project Funding

In accordance with the planned Project A launch dates of the mission schedule (Fig. A-1, Appendix A), a judgment is next made as to the fiscal distribution of the funding for these three types of spacecraft as component cost portions of the total project. These yearly amounts are also recorded in Table A-2 (Appendix A).

C. Total Project Manpower Requirement

As previously mentioned, manpower requirements (other than for SR, AD, and others) for the projects are determined by estimating the out-of-house funding fraction for that project and from the theoretical curves (Fig. C-1 and C-2 of Appendix C) estimating of the dollars per man applicable to the project. In the example case (Project A) the out-of-house funding fractions and dollars per man have been determined and are as shown in Table A-5 (Appendix A). From here, if we use the yearly funding figures involved, we can directly determine the yearly manpower requirements to accomplish the projects portion of the mission schedule. These manpower figures are recorded in Table A-3 (Appendix A).

D. Total Funding of Flight Mission Programs

Funding estimates are similarly made for the remaining projects of the complete program. A total project cost and the yearly funding distribution of that total is then determined by summing the yearly columns of Table A-2 (Appendix A).

E. Funding of Supporting Research, Advanced Development, and Others

The funding estimates for these activities are based primarily upon information from in house sources having direct experience in these activities. The criterion for these estimates has been based upon determining the sizes of mature research groups required for those technical areas in which we will probably be involved in any given year. Once the size of these individual groups and the total professional requirements are known, it is then possible to determine the total supporting research manpower required in a given year by multiplying the number of professionals by an appropriate number for direct (technical) and indirect support. (The factor used is 3.64, i.e., the assumed staffing ratio as of September CY-1.) The increase in manpower for supporting research (SR) across the years involved is assumed to be linear. Funding for SR is shown at levels indicated in current installation budget estimates for the last fiscal year and for the present one ($14,600 and $16,800 per man-year respectively). The succeeding fiscal years are at a level of $17,000 per man-year.

The advanced development (AD) funding and manpower requirements are based on the principle that the magnitude of the AD program should annually be some portion of the in-house development program. For the first two fiscal years (Table A-4, Appendix A), the AD funding and manpower requirements are those given in the respective installation budget estimates. From then on, it is assumed that AD funding will be at a level equal to one-half of the estimated in-house program funds. Referring to the theoretical relationship between out-of-house funding fraction and dollars per man-year in Appendix C (AD in the Financial Operating Plan for the FY just concluded was at the over-all rate of $19,800 man-year), it is assumed that this cost factor should be roughly $20,000 man-year for the current FY and from then on.

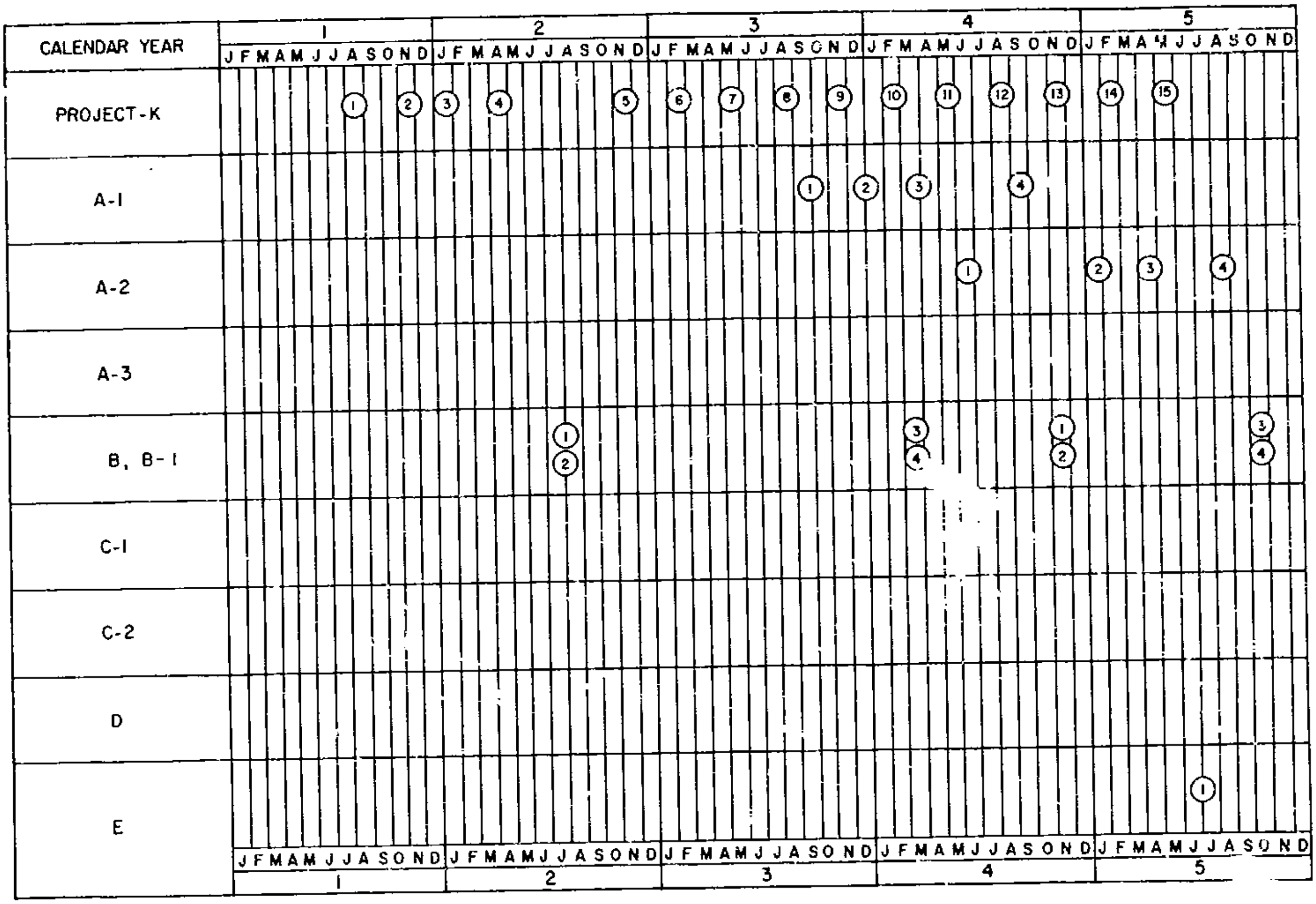
F. Total Installation Funding Requirements

The total funding for the fiscal years under consideration in this plan is determined by adding the increments for SR, AD, and others from Table A-4 (Appendix A) to the flight mission programs totals previously determined (see Table A-2, Appendix A).

G. Total Installation Manpower Requirements

Likewise, the total manpower requirement is the summation of the project increments and is shown in Table A-2 (Appendix A).

APPENDIX A. FUNDING AND MANPOWER REQUIRED FOR A TYPICAL LABORATORY MISSION SCHEDULE



I. TYPICAL FLIGHT PROGRAM

For purposes of estimating funding, manpower, and facility requirements, a project and mission schedule as shown in Fig. A-1 has been formulated. It is merely suggested that this schedule has the dimensions of a program which may emerge, and for which we may be responsible. Accordingly, funding and manpower estimates have been made corresponding to this schedule.

In order to test the sensitivity of manpower estimates to specific implementation plans, two alternative plans for the development schedule were considered. Each in a different way provided to some extent for focusing Installation in-house development on the apparently mo . advanced (and consequently more interesting) projects while at the same time maintaining reasonable continuity

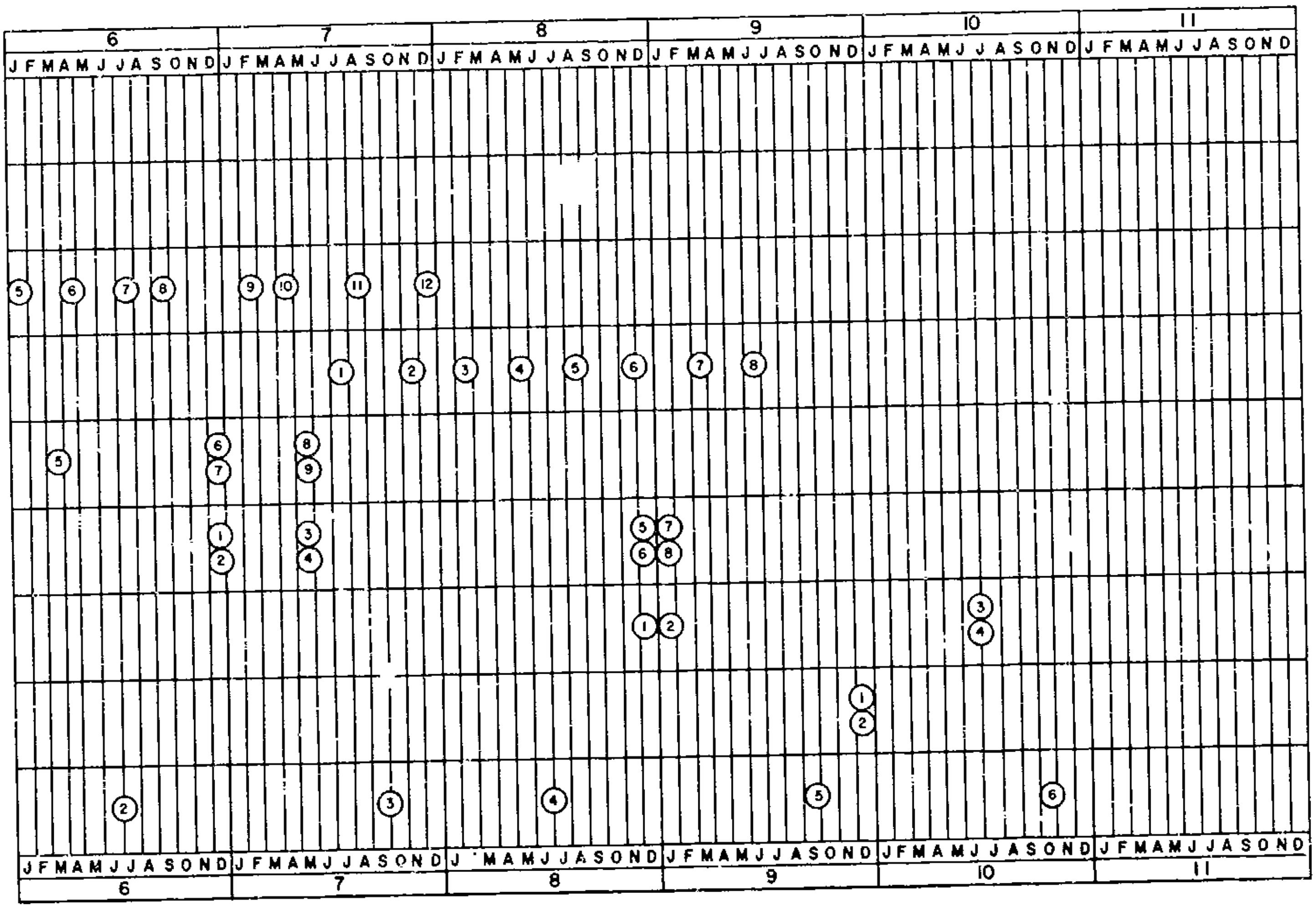


Fig. A-1. A typical mission schedule

of development engineering effort. From the standpoint of accuracy, the resulting estimates of required manpower were not judged to be significantly different. Accordingly, Tables A-1 to A-5 present a summary of the requirements for one such plan which may be considered typical.

II. MANPOWER AND FUNDING

Total funding and manpower figures include allowances for supporting research, advanced development, facility operations, and others as is indicated in detail in Table A-4.

Table A-1. Description and typical implementation of projects within the Flight Mission Programs

Project	Description	Implementation
Lunar Program		
K	K-3 to K-9 as presently defined; additional follow-on spacecraft K-10 to K-15 of the K-3 type with minimum modifications.	Out-of-house systems subcontract after approximately K-7.
A_1 (A_1C) 1-4	4 shots: Incorporating contractors electronic subsystems, but with structure and retro-propulsion subsystems redesigned for minimum mission of soft landing with 1 TV camera. Weight: 1000–1200 lb.	Out-of-house systems subcontract, taking advantage of the industrial competence already established.
A_2 1-12	12 shots: as presently defined.	Continued according to the present arrangement.
A_3 (C-1) 1-8	8 shots: Incorporating contractors electronic subsystems, but with structure and retro-propulsion subsystems redesigned and sized for increased landed payloads. Weight: 4500 lb. A third stage required.	Out-of-house systems subcontract, with the assumption that the additional third stage will be assigned elsewhere with direct funding.
B 1-4	4 shots: as presently defined.	In-house development.
B_1 1-9	9 shots: as presently defined.	In-house development, to take advantage of the detailed in-house familiarity with this spacecraft in meeting the fairly tight schedule.
Planetary—Interplanetary Program		
C_1 (C-1)	8 shots: dual capability. Weight: 3000 lb. Same third stage requirement as Project A (C-1).	Out-of-house systems subcontract, because of anticipated technological challenge, absence of long-term project growth potential, and phasing with Project B.
C_2 (C-4)	2 shots within decade—dual capability. To consist of a 3000-lb. mission capsule, containing most of the scientific instrumentation and collection equipment, and a bus of approximately 42,000 lb (including retro fuel).	In-house development for the mission capsule and out-of-house systems subcontract for the bus, mainly because of its size.
D (Hi-energy)	2 shots within decade: 2 separate 3000-lb spacecraft to probe the vicinities of planets. A top stage for the boost vehicle will be required.	In-house development, primarily because of the special technological challenges involved. Assumed that the systems responsibility for the top stage will be assigned elsewhere with direct funding.
E (Interplanetary)	6 shots: a series of probes utilizing basic spacecraft systems developed for other projects. Average weight: 1400 lb.	Spacecraft to be provided by systems subcontractors as a matter somewhat incidental to their application to other specific projects.

Table A-2. Total funding required for the typical Flight Mission Programs (spacecraft portion only)

Funding required for programs, not including SRT, or C of F.													
Project	Spacecraft weight, lb	No. of flights	$ K/lb	Total project cost, $M	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY 10
K 1-5	750	5	15	56	30	25	12	7					
K 6-9	750	4	8	24									
K 10-15	750	6	7	31									
A_1 (AgC) 1-4	1200	4	10	48	13	20	15						
A_2 1-12	2360	12	7	198	30	35	35	30	30	20	10		
A_3 (C-1) 1-8	4500	8	6	216	1	3	10	30	55	50	40	27	
B 1-4	450	4	16	29	13.5	11.5	4						
B_1 1-9	1400	9	11	139	17	30	35	30	20	7			
C_1 (C-1) 1-8	3000	8	9	216	1.4	5	20	40	50	40	40	21	
C_2 (C-4) 1-4	45000	4	9	1620		10	50	150	300	350	350	250	160
D	3000	2	18	108					1	10	30	30	20
E 1-6	1400	6	12	101		1	10	20	20	15	15	15	5
FLIGHT MISSION PROGRAM TOTAL		72		2066	106	140	191	307	476	492	485	343	185
Funding required for SRT													
Supporting research and technology					29	44	48	52	55	58	60	63	67
INSTALLATION FUNDING TOTAL					135	184	239	359	531	550	545	406	252

Table A-3. Manpower requirements for the typical Flight Mission Programs

Project	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY 10
K	833	538	138	68					
A_1 (AgC) 1-4	101	156	138						
A_2 1-12	234	195	195	167	167	156	135		
A_3 (C-1) 1-8	81	154	278	234	190	172	222	211	
B 1-4	520	442	186						
B_1 1-9	572	918	972	833	612	259			
C_1 (C-1) 1-8	114	139	156	138	172	138	222	211	
C_2 (C-4) 1-4		260	372	484	966	1030	1030	1290	1168
42,000-lb stage									
3,000-lb spacecraft		23	102	278	556	650	650	620	496
D					81	278	833	833	612
E 1-6		81	78	69	69	52	52	83	39
Program manpower total	2455	2906	2615	2271	2813	2735	3144	3248	2315
SRT	1580	1615	1853	2032	2220	2381	2524	3691	2859
INSTALLATION MANPOWER TOTAL	4035	4521	4468	4303	5033	5116	5668	5939	5174

Table A-4. Funding and manpower requirements for supporting research, advanced development and others

Activity		FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY 10
Supporting research.	$ M	8.2	9.5	11.6	13.7	15.6	17.6	19.6	21.6	23.6
	men	563	565	685	802	920	1037	1155	1272	1390
Advanced development.	$ M	12.9	13.0	13.2	13.5	14.0	14.5	15.0	16.0	17.0
	men	646	650	660	675	700	725	750	800	850
Operations and operational equipment.	$ M	5.5	18.9	20.2	21.4	22.0	22.5	22.5	22.[illegible]	23.7
	men	218	247	355	402	447	466	466	466	466
Others	$ M	2.7	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	men	153	153	153	153	153	153	153	153	153
TOTAL	$ M	29.3	44.4	48.0	51.6	54.6	57.6	60.1	63.1	67.3
	men	1580	1615	1853	2032	2220	2381	2524	2691	2859

Table A-5. Out-of-house fractions and expenditures per man-year for various projects

Project	FY 2	FY 3	FY 4	FY 5	FY 6	FY 7	FY 8	FY 9	FY 10
K 1-15	0.710	0.800	0.950	0.920					
	$K 36	46	115	103					
A_1 (AgC) 1-4	0.924	0.924	0.930						
	$K 128	128	109						
A_2 1-12	0.924	0.950	0.950	0.950	0.950	0.924	0.862		
	$K 128	180	180	180	180	128	74		
A_3 (C-1) 1-8	0.161	0.450	0.710	0.924	0.971	0.971	0.950	0.924	
	$K 12.3	19.5	36	128	290	290	180	128	
B 1-4	0.740	0.740	0.500						
	$K 38.5	38.5	21.5						
B_1 1-9	0.660	0.640	0.710	0.710	0.675	0.605			
	$K 33.6	30.6	36	36	30.5	27			
C_1 (C-1) 1-8	0.161	0.710	0.924	0.971	0.971	0.971	0.950	0.900	
	$K 12.3	36	128	290	290	290	180	99.5	
C_2 (C-4) 1-4 42,000 lb stage		0.710	0.924	0.971	0.971	0.971	0.971	0.950	0.924
		36	128	290	290	290	290	180	128
3,000-lb spacecraft		0.640	0.675	0.710	0.710	0.710	0.710	0.605	0.500
		30.6	32.7	36	36	36	36	27	21.5
D Hi-energy (C-4) 1-2					0.161	0.710	0.710	0.710	0.675
					12.3	36	36	36	32.7
E Interplanetary 1-6		0.161	0.924	0.971	0.971	0.971	0.971	0.950	0.924
		12.3	128	290	290	290	290	180	128

APPENDIX B. SPACECRAFT COSTS vs SPACECRAFT WEIGHT AND NUMBER OF FLIGHTS

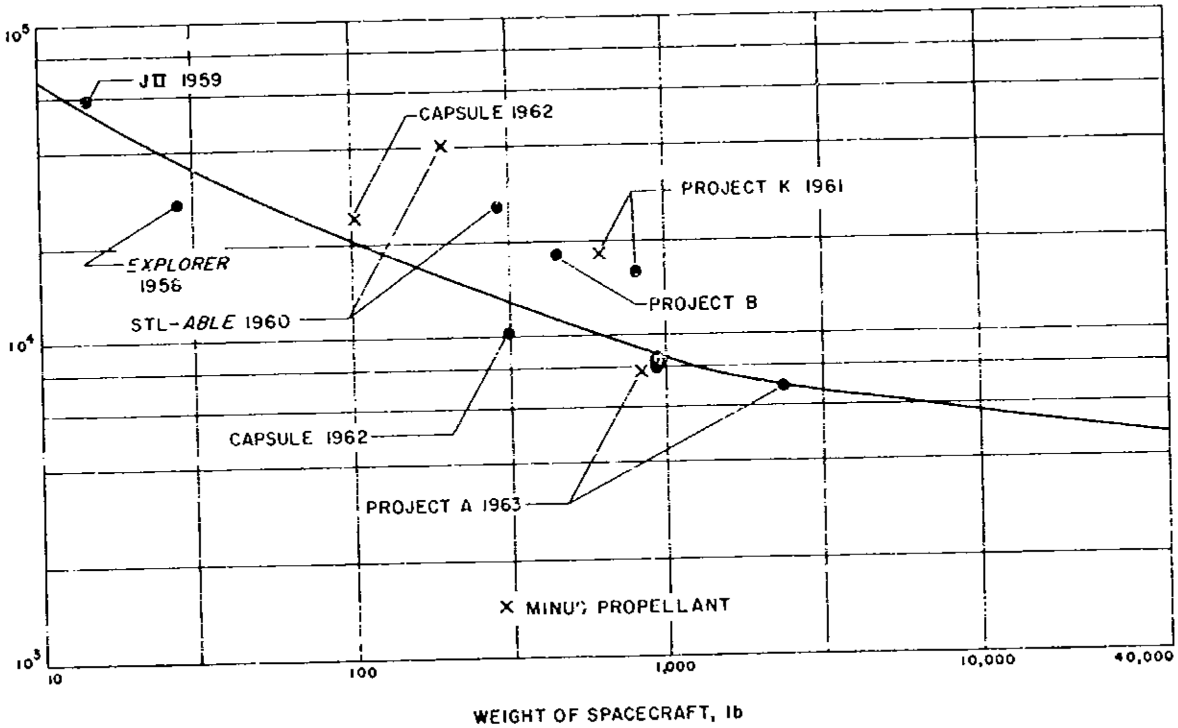


Fig. B-1. Spacecraft cost vs weight of spacecraft

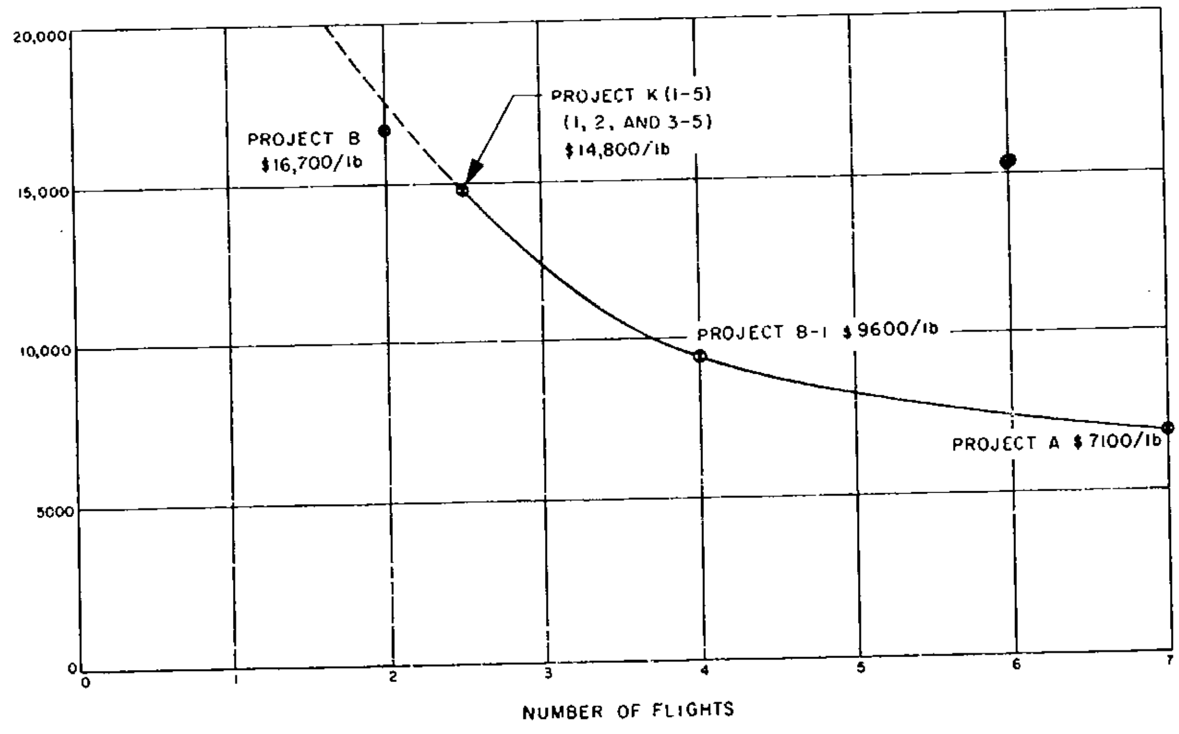


Fig. B-2. Spacecraft cost vs number of flights of a given spacecraft

APPENDIX C. RELATIONSHIP BETWEEN PROJECT MANPOWER COSTS AND OUT-OF-HOUSE FRACTION OF PROJECT FUNDING

A systematic analysis of the overall program funding for FY-1 and -2 has revealed a functional relationship between the average cost per man-year and out-of-house fraction of each program. In the discussion which follows, an attempt is made to interpret these findings in terms of their practical operational implications and to show how such information can be utilized in planning and estimating for the total program.

I. MANPOWER COST AS A FUNCTION OF OUT-OF-HOUSE FRACTION

The budgetary information obtained from actual operating experience during FY-1 and the financial operating plan for FY-2 when cast into manpower cost vs out-of-house fraction yields the correlation shown in Fig. C-1 and C-2. For the purpose of this analysis, the out-of-house fraction was taken as the ratio of procurement costs (both goods and services) to total program (or project) expenditure. The FY-1 cost per man-year was obtained by dividing the total FY-1 program (project) commitments by the total (average) manpower engaged in the program during FY-1. The manpower data were obtained from equivalent direct manpower figures selected at four times equally spaced throughout FY-1; indirect manpower was distributed by program in proportion to the direct manpower. The FY-2 cost per man-year was obtained by dividing the total program cost by the total (average) manpower required to conduct the program. This manpower figure was obtained by multiplying the estimated number of direct professionals by the installation average as of September FY-2 of 2.63 indirect support/direct professionals and adding the number of direct nonprofessionals.

The FY-1 and -2 data may be regarded as the "experimental" facts. It is apparent from this plot that there exists a functional relationship between the manpower costs and the out-of-house fraction. An elementary analysis readily reveals what this relationship must be.

Consider the quantity F—the total funds required to conduct a certain program—of which the fraction x is to be spent on procurements (for out-of-house services and hardware). Let $y(0)$ be the cost per man-year for an "entirely in-house" activity, and $y(1)$, that for an "entirely out-of-house" activity. Then the total manpower $m(x)$ (per year) required for this program may be expressed as

$$m(x) = \frac{Fx}{y(1)} + \frac{F(1-x)}{y(0)} \qquad \text{(C-1)}$$

Rearranging and solving for $F/m(x)$ yields

$$\frac{F}{m(x)} \equiv y(x) = \frac{y(0)}{1 - x + x\dfrac{y(0)}{y(1)}} \qquad \text{(C-2)}$$

This quantity is the average cost per man-year for a program which has an out-of-house fraction x.

The function $y(x)$ is the curve shown in Fig. C-1 and C-2. The two basic parameters required for obtaining this curve, $y(0)$ and $y(1)$, were taken to be \$10,850 man-year and \$1 million man-year, respectively. The first value was obtained by a least squares fit to the experimental points from the FY-2 operating plan. The same least squares fit resulted in a $y(1)$ value of \$1.04 million/man-year when the cost and manpower data for Project A were weighted three times their normal value in relation to the twelve other projects (programs). There are thirteen equations as follows:

$$\frac{8.533 \times 10^6}{y(0)} + \frac{21.120 \times 10^6}{y(1)} = 761 \text{ man-years}$$

$$\frac{2.168 \times 10^6}{y(0)} + \frac{30.782 \times 10^6}{y(1)} = 201 \text{ man-years}$$

$$\frac{0.051 \times 10^6}{y(0)} + \frac{1.650 \times 10^6}{y(1)} = 5.3 \text{ man-years}$$

$$\frac{5.563 \times 10^6}{y(0)} + \frac{7.923 \times 10^6}{y(1)} = 524 \text{ man-years}$$

$$\frac{6.046 \times 10^6}{y(0)} + \frac{10.668 \times 10^6}{y(1)} = 579 \text{ man-years}$$

$$\frac{0.298 \times 10^6}{y(0)} + \frac{0.058 \times 10^6}{y(1)} = 32 \text{ man-years}$$

$$\frac{2.056 \times 10^6}{y(0)} + \frac{0.645 \times 10^6}{y(1)} = 153 \text{ man-years}$$

$$\frac{3.262 \times 10^6}{y(0)} + \frac{5.851 \times 10^6}{y(1)} = 318 \text{ man-years}$$

$$\frac{0.888 \times 10^6}{y(0)} + \frac{2.187 \times 10^6}{y(1)} = 87 \text{ man-years}$$

$$\frac{1.803 \times 10^6}{y(0)} + \frac{1.151 \times 10^6}{y(1)} = 183 \text{ man-years}$$

$$\frac{0.859 \times 10^6}{y(0)} + \frac{0.359 \times 10^6}{y(1)} = 86 \text{ man-years}$$

$$\frac{1.299 \times 10^6}{y(0)} + \frac{0.658 \times 10^6}{y(1)} = 108 \text{ man-years}$$

$$\frac{6.114 \times 10^6}{y(0)} + \frac{2.086 \times 10^6}{y(1)} = 563 \text{ man-years}$$

The $1 million figure appears to be a reasonable round number based, in addition, on both installation and headquarters management experience. In the present context, a completely out-of-house program ($x = 1$) is one in which all services and hardware pertaining to a program are obtained from without the element directing the program. In this sense, the management of the installation (Senior Staff, Group Chiefs, and other top staff people) constitute a "program office" which manages the rest of the installation's efforts. Thus, some 125 people will manage in FY-2 some $124.2 million, or roughly $1 million/man-year. The Headquarters Staff plays the same role vis-à-vis all of the Centers, and the ratio of total Headquarters funds (exclusive of C of F funding) to Headquarters Staff ($1.521 billion to 1457 people) yields roughly this same value of $1 million/man-year.

The average cost per man-year for a completely in-house activity is a strong parameter in determining the function $y(0)$, and some care was exercised in obtaining a reliable figure. The $y(1)$ value, on the other hand, has a lesser influence in any "real" situation, that is, for any $x < 1$. For example, consider the computation of the FY-2 Project A manpower requirements for an out-of-house fraction of 0.924. For a total program funding of $32.95 million this yields $30.78 million out-of-house and $2.17 million in-house. Thus, 31 men manage the out-of-house effort and 231 men, the in-house effort, giving a total manpower complement for the Project A program of 262. Now if in place of $1 million for $y(1)$, a value of $10 million man-year had been used, the Project A manpower estimate would have been 3 man-years for out-of-house and 231 for in-house, giving a total complement of 234. This differs from the previous 262 figure by 11%. If the $y(1)$ value had been taken as $320,000/man-year, as an example of a large underestimate, the manpower figures would be 93 out-of-house and 231 in-house, giving a total of 324, or an error of 23%. In this example where the out-of-house fraction is very large, an underestimate of $y(1)$ by a factor of 3 yields a 23% error in total manpower; whereas an overestimate by a factor of 10 gives an 11% error. Thus, if the $1 million value is off by a reasonable amount, say a factor of 2, it would have little effect on gross program planning.

II. DISCUSSION

The purpose of the present analysis was to develop a method for estimating program (or group) costs which would be an improvement over the old practice based on a $25,000 man-year figure for an in-house type of activity and $250,000 man-year for an out-of-house activity. The analysis yielded three important results:

1. It showed that there is a relationship between the average cost per man-year of an activity and the fraction of the activity which is out-of-house.

2. This relationship can be represented by a continuous function which involves only two basic parameters.

3. This continuous function provides a uniform and consistent description of all activities of the Installation.

The existence of a functional relationship between average cost per man-year and out-of-house fraction was suggested by the experimental correlation shown in the figures. The use of the ratio of procurement costs to total costs as a measure of the out-of-house fraction was arbitrary; however, it is expected to be an adequate yardstick for comparative purposes.

The experimental correlation is supported by a mathematical treatment based on a simple funding model which postulates the existence of but two fundamental quantities: the cost per man-year of an entirely in-house activity, and the cost per man-year of an entirely out-of-house activity. The resulting expression for the average cost per man-year is given as a continuous function of the out-of-house fraction. Thus, one can describe a variety of activities with any arbitrary distribution of funds (in and out). In this context the distinction between an in-house and an out-of-house program is not as sharply drawn and, except for comparative purposes, not as useful. It is also clear now that the old method was but a crude representation by means of a step-function of the present more precise description.

The rather good comparison of the so-called experimental data and the theoretical relationship suggests the usefulness of this uniform approach in treating the total Installation program. Actually, the correlation need not be limited to analyses by programs. Correlation by work groups is also valid and perhaps even more informative. Figure C-1 shows such a graph, along with the appropriate points for various special projects. The correlation reveals that certain work groups (1, 2, 3, 4) exhibit a definite out-of-house character; whereas the others (5, 6, 7, 8) are, relatively speaking, the in-house elements.

It is important to point out that deviations from the curve merely reveal that the operation of certain activities differs from the average. This is to be expected because in this analysis the entire Installation—defined by projects or groups—was treated on a uniform basis. Detailed analysis shows that major deviations will occur, and for any number of reasons; for example, different burden rates or different ratios of support staff to direct professionals. To account for all these factors in an attempt at an even more precise treatment would be essentially a detailed re-analysis of each program (or division) director's effort. This is neither the motivation nor the purpose of the present approach. We present here simply a tool for quickly obtaining reasonable gross estimates.

III. CONCLUDING REMARKS

An analysis of the FY-1 and -2 experience and plans has revealed a functional relationship between average manpower costs and the out-of-house fraction. This correlation is explained by means of a simple funding model.

Comparison of the installation average figures for FY-1 and -2 shows a marked trend toward an increasingly out-of-house type of effort (by some 15%) with an attendant increase in average cost per man-year of from $25,000 to $34,400.

The theoretical curve should be of value to future planning. If kept up to date, it will provide a logical method for relating available program funds to manpower requirements. Thus, given a flight program and a means of estimating its cost in terms of the number of units to be delivered (cost per pound of spacecraft), one can determine in a straightforward manner the manpower requirements as a function of time, given the funding and out-of-house fraction as a function of time.

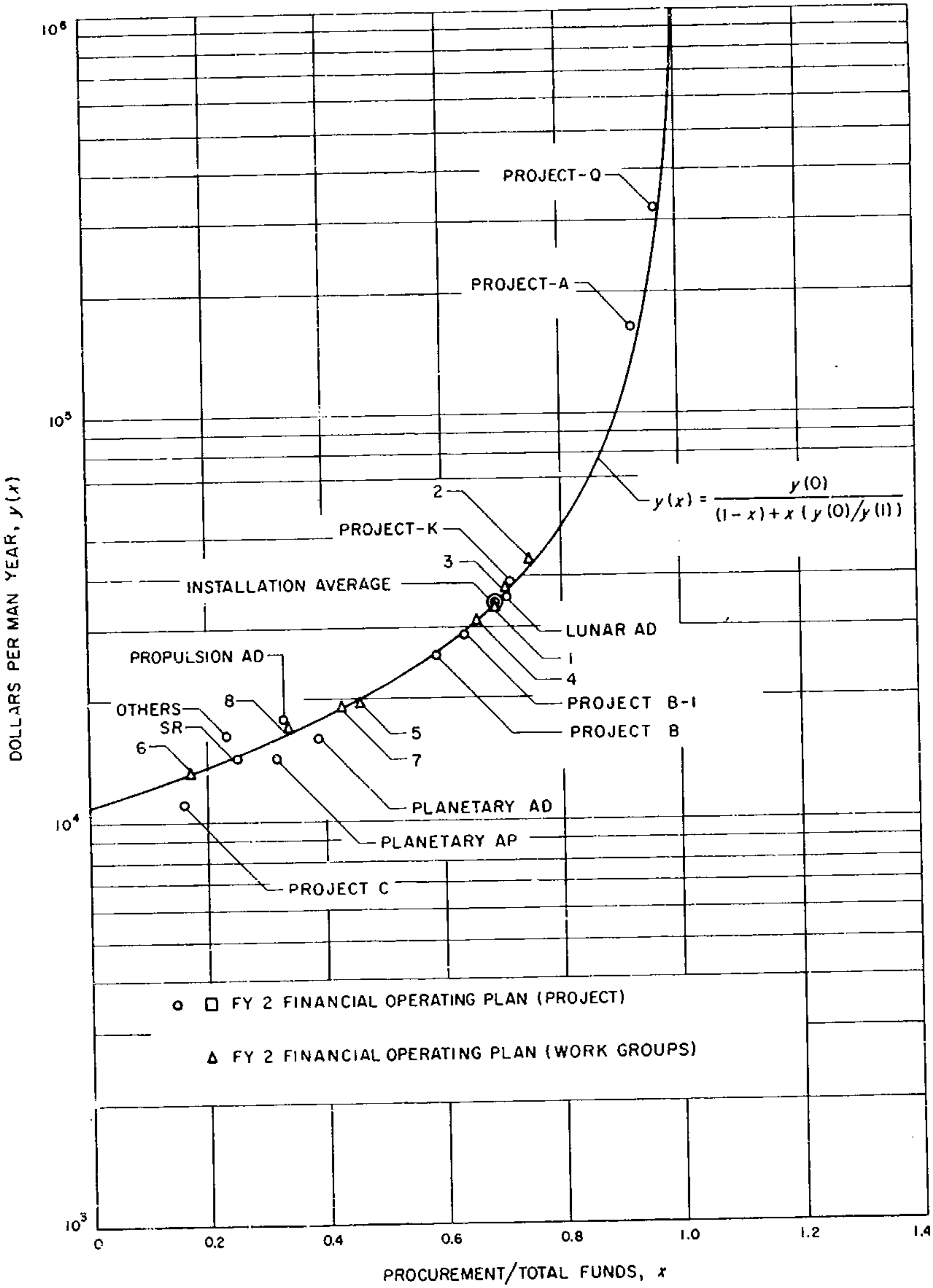


Fig. C-1. Relationship of the theoretical function y (x) to data from FY-2 financial operating plan

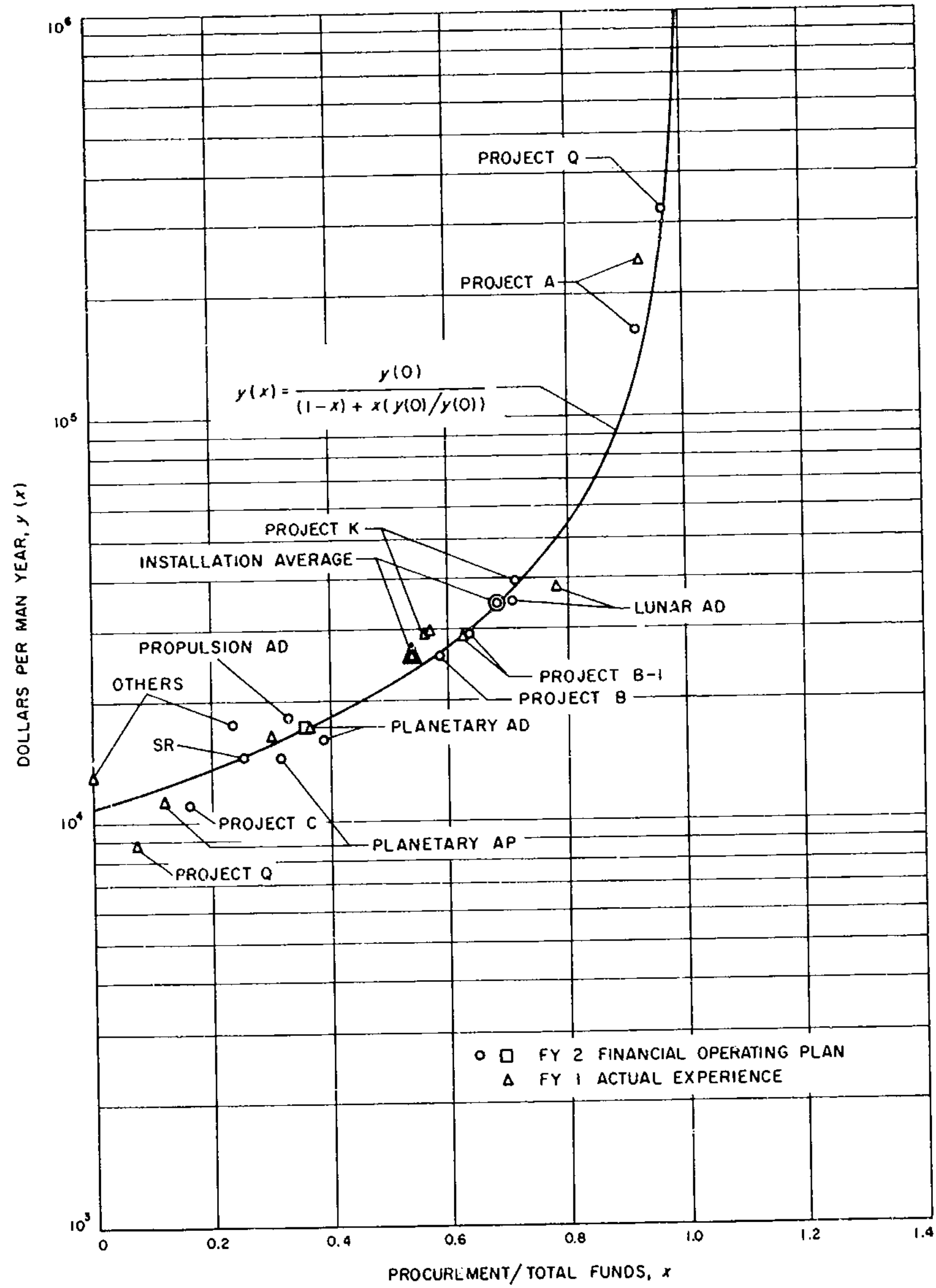


Fig. C-2. Relationship of actual funding and manpower experience during FY-1 to the FY-2 financial operating plan